

## The background.

Grafting is a method of asexual plant propagation that joins plant parts for them to live together. So they will grow as one plant. Normally the method has been largely applied to propagate trees that will not root well as cuttings or whose own root systems are not strong enough or resistant to several soil-borne pathogens. Now the use of grafted seedlings has been increasingly popular in the production of many fruit-bearing vegetables such as watermelon, cucumber, oriental melon, muskmelon, tomato, eggplant, and red pepper. The main purpose of grafted seedlings is to increase the yield and quality of fruits by combining a disease resistant rootstock with a genetically superior scion (Lee, 2003<sup>1</sup>).

A number of grafting methods have been employed. At any rate, good connection of vascular bundles between the rootstock and the scion is essential for successful grafting. When stocks and scions are attached, callus is formed in their cut surfaces. Then callus cells will differentiate forming the vascular connections between stocks and scions. The rate of attachment is based on environmental factors such as temperature and humidity in grafting facility.

Grafting of watermelon scions on squash, pumpkin, or bottle gourd (*Lagernaria spp.*) rootstocks is practiced in many of the major watermelon production regions of the world<sup>2</sup>. The primary reason for grafting of vine crops is to provide protection against soil-borne diseases (Edelstein et al. 1999<sup>3</sup>; Paplomatas et al. 2002<sup>4</sup>), but some rootstocks have the added advantage of being resistant to nematodes, especially the root-knot nematode *Meloidogyne* spp. Additional benefits include the potential for increased yield, increased fruit quality—especially flesh firmness, more vigorous plant growth and lower plant populations (Core

---

<sup>1</sup> Lee JM. 2003. Advances in vegetable grafting. *Chronica Hort.* 43:13-19.

<sup>2</sup> Kent Cushman, 2006. Grafting Techniques for Watermelon. Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. <http://edis.ifas.ufl.edu> .

<sup>3</sup> Edelstein M, R Cohen, Y Burger, SR Shriber, Pivonia S, Shtienberg D. 1999. Integrated management of sudden wilt in melons, caused by *Monosporascus cannonballus*, using grafting and reduced rates of methyl bromide. *Plant Disease* 83:1142-1145.

<sup>4</sup> Paplomatas EJ, K Elena, A Tsagkarakou, A Perdikaris. 2002. Control of *Verticillium* wilt of tomato and cucurbits through grafting of commercial varieties on resistant rootstocks. *Acta Hort.* 579:445-449.

2005<sup>5</sup>; Yetisir 2003<sup>6</sup>). Disadvantages included increased production cost and the possibility of altered horticultural characteristics of cultivars used as scions.

There are many conflicting reports on changes in fruit quality due to grafting. The differences in reported results may be due in part to different production environments, type of rootstock used, interactions between specific rootstocks and scions, and harvest date<sup>7</sup>. It has been reported that pH, flavor, sugar, color, carotenoid content, and texture can be affected by grafting vegetables and the type of rootstock used. Abnormal fruit quality issues reported for watermelon due to grafting include reduced soluble solids content, increased number of yellowish bands in the flesh, thicker rind, insipid taste, poor texture (more fibers), and decreased firmness (Lee and Oda 2003<sup>8</sup>; Alan et al. 2007<sup>9</sup>).

However, others report positive effects of grafting watermelon, including an increase in fruit firmness, Brix, and lycopene content (Davis and Perkins-Veazie 2005<sup>10</sup>). Perkins-Veazie et al., (2008) demonstrated that grafting watermelon could increase lycopene and total carotenoids by 20 %, and increased amino acids, especially citrulline (a non-essential amino acid with vasodilation properties), by up to 35 %<sup>11</sup>.

## Demonstration set up and results.

Though the use of grafted watermelon seedlings is a widely used practice in the most intensive agriculture areas of Albania, there are still many places where traditional production

---

<sup>5</sup> Core J. 2005. Grafting watermelon onto squash or gourd rootstock makes firmer, healthier fruit. Agric. Res. July issue.

<sup>6</sup> Yetisir H, N 2003. Rootstock resistance to fusarium wilt and effect on watermelon fruit yield and quality. *Phytoparasitica* 31:1-7.

<sup>7</sup> A.R. Davis, C.L. Webber III, P. Perkins-Veazie, V. Ruso, S. Lopez Galarza, and Y. Sakata. 2008. A review of production systems on watermelon quality. *Cucurbitaceae 2008, Proceedings of the IXth EUCARPIA meeting on genetics and breeding of Cucurbitaceae* (Pitrat M, ed), INRA, Avignon (France), May 21-24th, 2008.

<sup>8</sup> Lee JM, Oda M (2003) Grafting of herbaceous vegetable and ornamental crops. *Hort. Rev* 28:61-124.

<sup>9</sup> Alan Ö, Özdemir N, Günen Y (2007) Effect of grafting on watermelon plant growth, yield and quality. *J Agron* 6: 362-365.

<sup>10</sup> Davis AR, Perkins-Veazie P (2005-2006) Rootstock effects on plant vigor and watermelon fruit quality. *Cucurbit Genet Coop Rep* 28-29: 39-42.

<sup>11</sup> A.R. Davis, C.L. Webber III, P. Perkins-Veazie, V. Ruso, S. Lopez Galarza, and Y. Sakata. 2008. A review of production systems on watermelon quality. *Cucurbitaceae 2008, Proceedings of the IXth EUCARPIA meeting on genetics and breeding of Cucurbitaceae* (Pitrat M, ed), INRA, Avignon (France), May 21-24th, 2008.

technologies are dominating. AAC intervention aimed the introduction of grafted seedlings into production areas that currently do not extensively use this technology. Some attention was also addressed regarding to differences exist between commercially grafted seedlings versus farm grafted seedlings.

Two demonstration plots were settled during 2009, respectively in; Berat (Ciflik) and Fier (Frakulle). Good farmers were selected based on a share cost agreement. The growers was asked to provide one hectare of land, labor and input costs, including his own seedlings, while AAC has provided the cost of grafted seedlings.

The expected outcomes of the proposed technology were;

1. Improved operational efficiency/productivity.
2. Expanded market opportunity (earliness).
3. Increased farmer's sales.
4. Increased profit due to price premium.

The planned parameters to be recorded included; days to first flowering, days to first/last harvest, the incidence of pests and diseases, marketable yield and the respective prices. The data recorded during the demonstration periods are shown in table 1;

As it is presented in table 1, grafting had no influence on flowering time, but there was a significant difference of 3 to 5 days on the date of first harvest. These days might provide a significant price premium, especially in case of earlier transplanting dates. The use of grafted seedlings demonstrated quite visible advantages in terms of production yield, too. There was recorded a difference of 15 to 20 ton per hectare compared to control (non – grafted seedlings).

Table 1. Phenological and production data of grafted and non-grafted watermelon seedlings at different demonstration sites.

Demonstration site	Demonstration variant	Transpl. date	Flowering date	First harvest date	Yield (ton/ha)	Price (ALL/ton)
Berat (Ciflik)	Comerc. grafted	March 12	May 5	June 15	70	18500
	Non grafted	March 12	May 5	June 20	53	17200
Fier (Frakulle)	Comerc. grafted	March 16	May 5	June 14	72	18500
	Non grafted	March 16	May 5	June 18	50	17200

Similar results were reported by Alan, et.al, 2007, in both open field and low tunnel growing conditions. In experiments conducted with cv. Crimson Tide grafted with different rootstocks,

a significantly higher yield (kg/plant) was recorded each time compared to non-grafted seedlings. As it obviously can be seen, the higher yield was obtained due to both, increased fruit number per plant and increased fruit weight.

Table 2. Yield characteristics of grafted and non-grafted watermelon plants (Cv. Crimson Tide grafted on different rootstocks, adopted from Alan, Ozdemir and Gunen<sup>12</sup>).

Treatment	Fruit yield (kg/plant)		Number (fruits/plant)		Fruit weight (kg/fruit)	
	Low tunnel	Open field	Low tunnel	Open field	Low tunnel	Open field
C (control)	7.25	8.98	1.78	1.48	4.08	6.45
C / 64-18	10.95	14.20	2.28	2.35	4.60	6.28
C / TZ-148	17.70	18.95	3.60	3.38	4.93	6.15
C / RS-841	20.13	17.95	3.70	3.75	5.43	6.35
LSD 5(%)	4.48	2.76	0.66	0.66	0.41	NS

Taking about grafted watermelon seedlings, the influence of specific rootstock types and appropriate rootstock-scion combination must be considered. As it was reported by Yetisir and Sari<sup>13</sup> (2003), there is a great effect of specific rootstocks on grafted watermelon performance. Their results showed that while survival rate was low (65%) in *Cucurbita* type rootstocks, it was high (95%) in *Lagenaria* type rootstocks. Generally speaking, grafted plants flowered about 10 days earlier and showed more vigorous vegetative growth than the control plants. Grafted plants had up to 148% higher fresh weights compared with control plants. Similarly, grafted plants showed 42–180% higher dry weight, 58–100% more leaves and larger leaf area as compared with the control. In total yield, *Lagenaria* type rootstocks produced a higher yield but *Cucurbita* type rootstocks produced a lower yield than the control. While control plants had 6.43 kg/m<sup>2</sup> yield, *Lagenaria* type rootstocks produced 27–106% higher yield than the control. In contrast, *Cucurbita* type rootstocks had 127–240% less yield than the control. This could be attributed to incompatibility of *Cucurbita* rootstocks because some of the plants in their experiments died before harvest.

Similar demonstrations were conducted to compare farm grafted versus commercially grafted watermelon seedlings, based on the fact that in some villages is a custom practice the use of farm produced non controlled (wild or F<sub>2</sub>) rootstocks. The demonstration was aiming to estimate the respective effects on yield, earliness, compatibility and taste.

<sup>12</sup> Alan O, Ozdemir N and Gunne Y, 2007. Effects of grafting on watermelon plant growth, yield and quality. Journal of Agronomy 6(2): 362-365.

<sup>13</sup> Yetisir H & Sari N, 2003. Effect of different rootstock on plant growth, yield and quality of watermelon. Australian Journal of Experimental Agriculture 43(10) 1269 - 1274

As it might be seen from the table 3, there were differences regarding the date of first harvest and yield. A higher market price was recorded due to earliness, and consequently the market revenues and profits were much higher in case of commercially produced seedlings. The slight increase of production cost, due to higher price of commercial seedlings, is easily recovered by higher yield and better price. Meantime, there was largely evidenced the general perception of lower quality fruits (due to some not appreciable aromas) from farm produced seedlings.

Table 3. Phenological and production data (first harvests) of farm grafted and commercially grafted watermelon seedlings at different demonstration sites.

Demonstration site	Demonstration variant	Transpl. date	Flowering date	First harvest date	Yield (ton/ha)	Price (ALL/ton)
Berat (Ciflik)	Comerc. grafted	March 15	May 5	June 17	41	18500
	Farm grafted	March 15	May 5	June 22	35	17690
Fier (Frakulle)	Comerc. grafted	March 20	May 5	June 20	38	18500
	Farm grafted	March 20	May 5	June 23	32	17690

Assuming an equal use of agricultural inputs (fertilizers, pesticide, water) and similar technology of production, the use of grafted versus non grafted seedlings is fully justified from the financial point of view. Despite the fact, that there is a considerable increase in direct production costs due to much higher (5 times more) cost of grafted seedlings, still the market revenues and incomes of grafted watermelons are much higher compared to non grafted ones (Table 4). Apart from the safety reasons (less incidence of diseases and higher resistance to adverse climatic conditions) this is the main reason that grafting is actually a wide spread agronomy practice.

By farm grafting the watermelon growers tend to reduce the high cost of commercially grafted seedlings. Sometimes they do it successfully. One should note that, whether the quality rootstocks and proper rootstock-scion combination is applied there is no significant reason not to have good quality farm grafted seedlings. The problem starts with the poor quality; self produced rootstock seeds, which do not guarantee uniformity and appropriate protection against soil borne diseases and adverse weather condition. Under these circumstances the harvested yield was lower compared to commercially grafted seedlings (Table 4), fruit setting was not uniform resulting to smaller early production and quality of fruits was diverse. Still, though a higher yield was recorded by commercially grafted seedlings, in terms of financial efficiency (incomes generated for one Euro expended), farm grafting practice is highly competitive. No doubt, comparing to non grafted seedlings even farm grafted ones offer much larger possibilities (Table 4).

Table 4. Summary of crop expenditures and incomes (euro)				
<b>Incomes</b>				
Planted area (sq.m)	10000	Grafted seedlings	Farm grafted seedlings	Non grafted seedlings
<b>Yield (kv)</b>		<b>660</b>	<b>528</b>	<b>400</b>
<b>Average price (ALL/kv)</b>		<b>1850</b>	<b>1769</b>	<b>1720</b>
<b>Sell's incomes</b>				
Watermelon		9768	7471	5504
<b>Total sells</b>		<b>9768</b>	<b>7471</b>	<b>5504</b>
<b>Direct costs</b>				
Machinery costs		187	187	187
Labor		1455	1253	1066
Seedlings		<b>1400</b>	<b>420</b>	<b>320</b>
Fertilizers		960	960	960
Pesticide		120	120	120
Fuel			0	0
Electric power		800	800	800
Plastic films		520	520	520
<b>Total of direct costs</b>		<b>5442</b>	<b>4259</b>	<b>3972</b>
<b>Indirect and administrative costs</b>				
Depreciation		142	142	142
Maintenance		0	0	0
Administrative costs		100	100	100
Non planned costs		263	204	189
<b>Total of indirect costs</b>		<b>505</b>	<b>446</b>	<b>432</b>
<b>Incomes without interests and taxes</b>		<b>3821</b>	<b>2766</b>	<b>1100</b>
Bank interests costs		0	0	0
Taxes		0	0	0
Credit loans		0	0	0
<b>Total expenditures</b>		<b>5947</b>	<b>4705</b>	<b>4404</b>
<b>Net incomes</b>		<b>3821</b>	<b>2766</b>	<b>1100</b>

## Discussion and recommendations.

The use of grafted watermelon seedlings is a successful growing practice. The grower's benefits are especially higher under adverse growing conditions, including non availability of plant rotation, high soil infestation rate from soil borne diseases, lack of appropriate land drainage, high salinity content, and etc. Actually, while many powerful soil disinfectants are banned, the use of highly resistant rootstocks remained almost the only solution for several specific circumstances.

Grafted watermelon seedlings provides higher yield, compared to non grafted ones. It is achieved from both, increased fruit number per plant and increased weight (size) of individual

fruits. Keeping this in mind one should note, that contrary to the common past demands, nowadays, the local/regional consumer's preferences are shifting from big size fruits to medium ones. New potential markets are even demanding for small size (personal) watermelons. Consequently, this calls for searching/demonstrating the most appropriate rootstock-scion combinations and/or the most appropriate planting densities providing higher yield based on the increase of fruit numbers per plant without affecting (preferably reducing) fruit size.

There are long disputes about the role of grafting on watermelon fruit quality. One might conclude that potentially grafting can positively or negatively affect watermelon fruit quality depending on appropriateness of rootstock-scion combination and growing conditions. This risk is increased in case of farm grafting practices due to lack of uniformity of self produced rootstock seeds. To enhance the positive effects of grafting on watermelon quality calls for additional search/demonstrations on several cultivation practices (irrigation regime and crop nutrition regarding to specific soil conditions, planting density, plant pruning, etc).

The role of different rootstock types (*Lagenaria* versus *Cucurbita*) is under estimated in commercial seedling production in Albania and their specific effects on production yield and quality are not known. It will be on the benefit of watermelon producers searching/demonstrating the specific soil/environmental/agronomical circumstances each type of rootstock types should be used. Introducing new type and/or new rootstock cultivars will increase the menu of choices for specific growing/marketing circumstances.

The use of grafted watermelon seedlings is economically justified. Despite much higher cost of commercially grafted seedlings the market revenues and incomes per unit of land area are considerable higher and much more guaranteed.

The AAC intervention was feasible and justified. It provided to the watermelon growers some more evidence based results and appropriate conclusions regarding the efficiency of grafted watermelon seedlings. There is a need to go further, elaborating some more specific details which will contribute upgrading the watermelon production technology in Albania. This calls for more search/demonstration activities regarding to;

- Introduction of new type and/or new cultivars of watermelon rootstocks,
- Identifying the specific circumstances each rootstock type/variety should be used,
- Identifying the most appropriate rootstock-scion combinations providing the highest yield and best marketable fruit quality (this is especially an emergency for new triploid cultivars which are becoming the new trend of watermelon production in Albania).